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Management implications of neotectonic activity at Minnipa Hill, north-western Eyre Peninsula, South Australia

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Abstract

An earth tremor which occurred on 19 January 1999 caused the development of a suite of small neotectonic landforms on Minnipa Hill, a low large-radius granite dome located near the town of Minnipa, on north-western Eyre Peninsula, South Australia. This event and its results carry several implications for the utilisation and management of such granite rocks, as well as being germane to the interpretation of several familiar landforms.

Keywords: granite outcrops, compressive stress, neotectonism, quarrying, hazards

Introduction

Minnipa Hill is one of several domical hills or bornhardts located in the Minnipa and Wudinna districts of north-western Eyre Peninsula, South Australia (Fig 1; Twidale 1964; Twidale & Campbell 1985). It consists of two separate exposures, locally referred to as the western and south-eastern rocks. Minnipa Hill South-east is an outcrop of massive impermeable granite exposed on the crest and eastern slope of the rise. In vertical section about 12 m of rock are exposed. It is delineated by prominent NW-SE and NE-SW trending fractures. Some of the lower slopes are flared.

The tremor and resultant forms

An earth tremor, estimated at about 2.3 on the Richter Scale, shook Minnipa Hill South-east in the late morning (1137 CDST) of 19 January 1999 (Twidale & Bourne 2000a). The tremor was shallow, so that most of the energy generated in the shake was dissipated at the surface. The quarrymen working at the site heard a loud bang just before the lunch break, and on investigating the hill upslope from the working area found the surface disturbed over an area about 170 x 120 m (Fig 2). The tremor caused several rock bursts, with the disruption of large blocks of granite (C2-C6 in Fig 2). For example, a block weighing some 730 kg was displaced 58-100 cm; a triangular slab weighing about 880 kg located low on the eastern slope was moved laterally up to 28 cm; one slab was displaced laterally leaving a quadrangular void some 20 x 90 x 25 cm. This movement was down a 4° slope and involved the displacement of slabs that in total weigh about 3330 kg. A block weighing some 110 kg jumped about 75 cm up a 7° slope (*cf* Ikeda 1996). In addition small fragments and flakes of rock were flung up to 25 m from the centre of the largest rock burst (C3 in Fig 2). Several low (up to 12 cm) fault scarps were formed, two of them in parallel and delineating a low amplitude horst. Huge flat-lying slices or wedges of rock were moved laterally (by 1-2 cm) relative to those below them. Two new A-tents were formed and widespread flaking of the rock was evidenced.

This was not the first earth tremor to affect the Hill, for evidence of at least two similar assemblages of superficially weathered and discoloured forms - flakes, displaced slabs, A-tents - are preserved at the site (C1 in Fig 2).

Management implications of the tremor

The Minnipa Hill bornhardt is typical of its type both in morphology and in origin. It is neither as extensive and high, nor as intricately sculptured, as are Ucontitchie and Wudinna hills, for example, but the component parts are typical of the many low "dimpled and grooved" (because of the development of numerous basins, or gnammas, and gutters or *Rillen*) domes that are exposed not only on north-western Eyre Peninsula but also in the Yilgarn, Pilbara and Salinaland divisions of Western Australia (see *e.g.* Jutson 1914). As to origin, most though not all bornhardts are upstanding because they are massive with few open fractures, so that water cannot readily penetrate and rot the rock. They are massive because they are in compression (Twidale 1964, 1982a,b; Vidal Romani & Twidale 1998; Twidale & Vidal Romani 1999). By contrast the granite of the plains is densely fractured so that water can penetrate and alter the granite. As far as is known, all the granitic bornhardts of Eyre Peninsula and the Wheatbelt area of Western Australia are of this type, and the recent development of A-tents, reverse fault scarps and slipped slabs shows that many have been and that some still manifestly are tectonically active (*e.g.* Twidale 1986; Twidale *et al.* 1991, 1993).

Granite hills possess different qualities but they are all subject to competing interests. In particular they are of potential value for quarrying, water conservation, tourism, local recreation, biological conservation and scientific research. In 1913, for example, Minnipa Hill was used as the catchment for a small water conservation scheme to supply water for the steam engines running on the then newly extended railway line from Port Lincoln (Twidale & Smith 1971). The eastern slopes of a small outcrop located some 200 m south of Minnipa Hill have been dammed and used for collecting water for stock. Minnipa Hill is the site of a microwave tower, because it

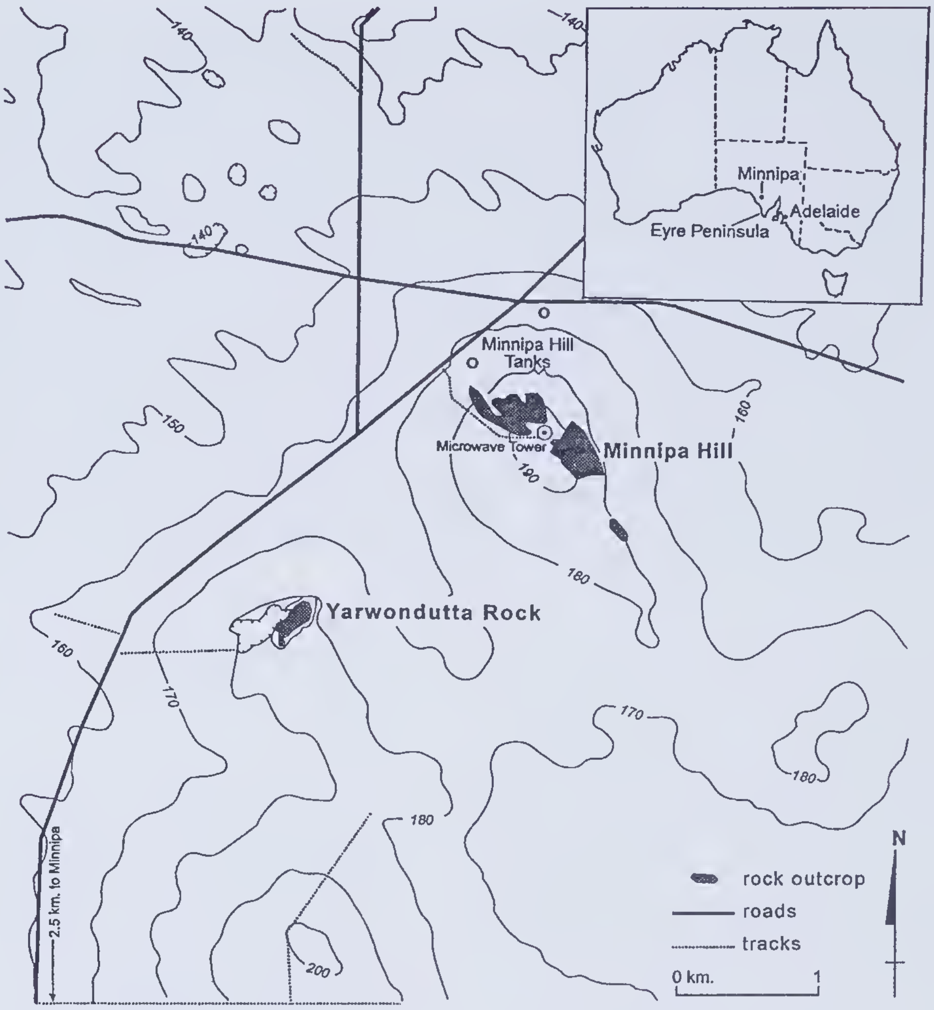

Figure 1. Location of Minnipa Hill, north-western Eyre Peninsula, South Australia.

is a local eminence, is geographically and legally accessible, and is not a recreation area. Quarrying for monumental stone began at the site in 1998.

Earth tremors such as that which affected Minnipa Hill on 19 January 1999 have implications for several of the possible uses to which granite hills are put. Prior to the tremor the quarrymen working the Minnipa Hill South-east quarry experienced operating difficulties. The rock adjacent to cut slots disintegrated to a depth of several centimetres, the bridges between drill holes (which became distorted) crumbled and there were minor rock bursts. All these are indicative of rock in compression. Quite apart from operating difficulties, rock bursts are dangerous to workers and anyone else who happens to be at the site at the time (see *e.g.* Isaacson 1957; Leeman 1962). The potential occurrence of rock bursts is also a cause for concern for tourist operators but the chances of them taking place where and when visitors are present at the sites is remote, and certainly less than other everyday hazards such as tripping, falling and breaking bones. On the other hand, displaced slabs at several sites (Little Wudinna Hill on north-western Eyre Peninsula, King Rocks and Hyden Rock in the Wheatbelt, The Granites near Mt Magnet in Salinaland) and fault scarps at King Rocks and Hyden Rock (Twidale *et al.* 1991; Twidale & Bourne 2000b), for example, show that earth tremors are not uncommon and that trails and paths for visitors ought not to be situated below perched slabs or boulders.

Albeit at a minor scale, the Minnipa Hill tectonic event also illustrates the possible problems posed by earth tremors for water conservation schemes. The floors and walls of several small rock basins (*e.g.* pan *in* Fig 2) were cracked and breached so that they no longer hold water. Sediment which had accumulated in the floors has been flushed away. Man-made structures, from dams to retaining walls, are similarly at risk.

Tectonic events like that evidenced at Minnipa Hill have the potential temporarily to disturb biological niches, for instance by causing arches and slabs to collapse and by rupturing the root systems of plants. Biological niches have been destroyed. On the other hand new ones were generated as slabs were arched and blocks pulled apart.

Such events are useful also in providing data relevant to various scientific controversies. Thus the event of 19 January 1999 at Minnipa Hill South-east is pertinent to the debates concerning the origin of bornhardts, sheet structure and A-tents (see *e.g.* Dale 1923; King 1949; Twidale & Sved 1978; Twidale 1980, 1982 a,b; Wallach *et al.* 1993; Twidale *et al.* 1996).

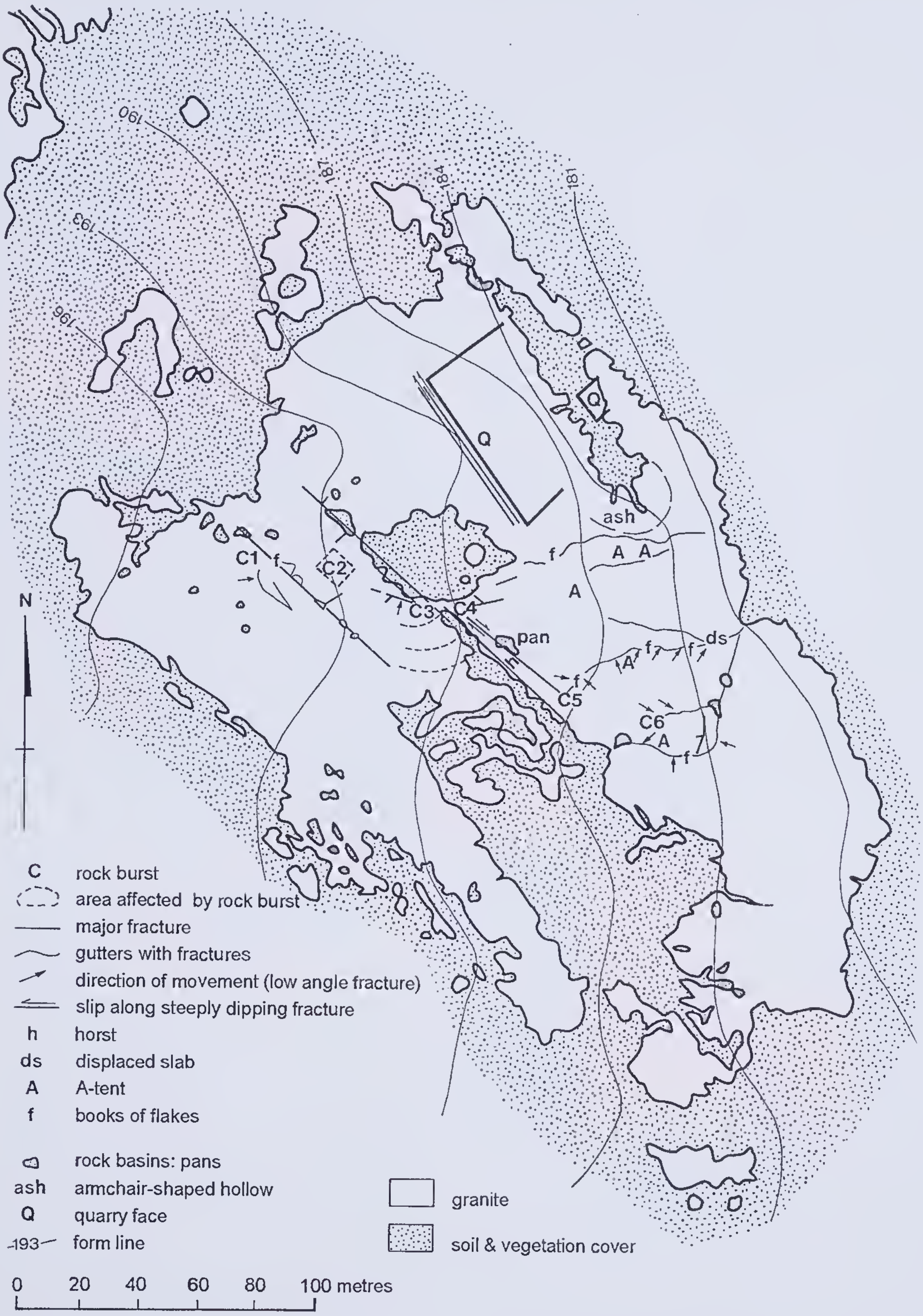

Figure 2. Map of Minnipa Hill South-east showing neotectonic forms resulting from the tremor of 19 January 1999.

Most granite hills are hills because they are in compression, are massive and are not penetrated by the water that is mainly responsible for rotting the bedrock and transforming it into a state in which it can be worn away. Both general theory and the site evidence show that granite hills are subject to disturbance by earthquakes and earth tremors, and mapping and analysis of the surface morphology show that their impacts have been experienced several times and hence are likely to recur in the future. Such possibilities ought to influence management plans, for the field evidence is clear.

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